December 19, 2011

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 440 Functional Specifications for a Bed Side Assistance System

Dear Dr. Rawicz,

I have attached a copy of the Post Mortem documentation, Post Mortem for a Bed Side Assistance System.

The document enclosed outlines the ideas, methods and requirements that our project must satisfy to meet the end goal. The goal of this project is to create and design a device that will assist a patient which is having difficulties positioning their lower body (leg region) into bed due to other alignments that prevents them from doing so comfortably on their own. The device is designed to allow the patient to start in a sitting position from the bed side and have their legs lifted up and over onto the bed where they are allowed to maneuver themselves as needed for their comfort. All of this is controlled by a controller unit which the patient uses to operate the device at their own pace so the patient is never put into a situation where they feel uneasy or uncomfortable during the process.

This document includes the current state of the prototype created and the current operations it holds. It describes how the prototype has evolved through the course of the term from the initial beginnings of designing to the end result of the prototype and what changes have been made because of the evolution of the project with the reasoning behind them. Finally, we will touch on our personal experiences of this project and how we did or felt going through this term.

AMMA Tech consists of the following members: Michael Quong, Martin Wong, Andrew Yip and Amer Kalla. For any inquires about the company, project or individuals, please feel free to contact us at mqa1@sfu.ca.

Sincerely,

Michael Quong

Michael Quong
AMMA Tech – CEO

Post Mortem for a Bed Side Assistance System

Project Team:
Michael Quong – 301041935: mqa1@sfu.ca
Martin Wong – 301043629: mqw@sfu.ca
Andrew Yip – 301047570: awy2@sfu.ca
Amer Kalla – 301096288: aka68@sfu.ca

Contact person:
Michael Quong – mqa1@sfu.ca

Submitted to:
Andrew Rawicz – ENSC 440
Mike Sjoerdsma – ENSC 305
School of Engineering Science
Simon Fraser University

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1.0. Introduction

AMMA Tech. created a bed side assisting system that would provide a solution to those that had difficulty getting into bed under their own strength due to a complication that would prevent them from doing so. It is a system that we have put in countless hours and work into developing how the device will function and how it will operate. Although it was a challenging project for our team to create, we took it in stride to make the best of what this project can be. Over the course of the term, our project evolved greatly from our initial visions to what it has ended up looking today. This report will look into some of these evolutionary changes and how it could look like in its future.

2.0. Current State of Project

2.1. Frame Design

The system is made of three main parts: the arm, the leg and the body. These parts are design to make it simple to assemble together for portability purpose. The arm is responsible to lift the leg of the user onto the bed by using the linear track actuator to push it diagonally and rotate at most 90 degree to lift the legs. The legs are the support for the system. Another linear track actuator is attached to one side of the legs and is positioned in an inclined position to convert the linear track motion into rotational motion. There is also a wooden handle bar attach to one side of the leg to allow the user to use to support the upper body when the system lifts the legs. The last component is the body, which used to stabilize the legs together from moving and locks the arm in place between the legs. The frame of the system is designed in wood and attached with screws

2.2. Hardware

The electronics for our prototype build consists of three layers which contain circuits that when connected together control the logics that run our system overall. The core of our system is comprised of our Arduino UNO microcontroller which was used to hold our software and listen for manual control inputs from the user. Depending on the type of input coming from the controller the microcontroller would respond to it as programmed to produce an effect that we desired. The second section of our system consisted of our motor driver which was an Ardumoto driver. This driver gave us the ability to control the direction of rotation of each linear actuator and at the speeds we needed the actuators to move at. The driver circuit also allowed us to feed a larger supply voltage which we required to run our components while decreasing the risk of harming other more delicate parts. The third section consisted of our circuit components on a PCB which helped connect the logical signals of our microcontroller to the button switches on our controller.

In terms of the sensors for our system, we have two force sensitive resistors which help notify when our lift system has reached the top most limit of the system and when it has reached the bottom most limits. These limits are predefined by the placement of our force sensitive sensors on our system.

The button switches used for the controller are simple push down buttons. Once a button is pressed down, it will lock itself into position and allow the system to operating depending on the functionality that switch controls. Pressing the button once again, will release the switch from its original position and turn off the functionality that it was currently controlling.

2.3. Software

Current the software version of the program has performed as expected for the system. The requirements for the software were not really complex so only a simple program was needed. The program performs well and does what it is intended to do with no errors. Currently the software is able to read user input and use that to control the two motor. It is able to move both motor at once by switching between the two motor quickly. It can also read interrupt and stop the motor when needed. Corner cases have been address, so there is currently no unexpected problem with special cases.

2.4. Motors

In our prototype design, we used two linear actuators to complete our desired motion. The motion required is a 3D motion that starts at the bottom right of the device up and outwards in a curve to right the top left of the device. For this motion to occur, one linear actuator was used to push the leg pad from one corner to the other and the other actuator pushed the leg pad and the first actuator outwards and up.

3.0. Problems Encountered

3.1. Mechanical Issues

The frame of the system is entirely based on mechanical structure. Designing the mechanical is simple as drawing how the system look on paper, however, when the time comes to building the system, there are mechanical issues that thought to work and did not work after building stage. One of the issues is the rotation motion required for lifting the arm of the system. The system is required to lift the legs 90 degrees and maintain the position for a period of time. With the constraints such as space limitation, there are possible designs that we came up with; however, these designs may or may not work without proper test. Upon this issue, another issue must be considering is the weight of the arm and how to maintain the weight of the arm.

In most case, a solution can solve an issue to a mechanical problem, but there are also cases where one solution leaded to another problem. For the rotational motion issue, the solution to get the rotation movement by using a linear track actuator. By setting the linear track actuator in an incline linear movement, the actuator can push another track that attached to the rotation object. The joint of the two tracks must be able to slide and rotate in order to get the rotational motion. Since the linear track actuator is in an incline position, this position can act as a support pillar for the weight of the arm issue. Even though the rotational motion and weight have been deal with, another issue has arise; the joint of sliding will have a huge amount of friction that will prevent the system to slide. A solution that have been consider is by reducing the friction of the track using a type of lubricant and this lubricant must be able to stick to the track.

Another issue in the mechanical of the system is the material used to build the system. For the prototype of the system, we have used wood because of the affordability and durability; however, without proper experiences of handling this material, there have been many failed attempts when building certain part of the system. The failed attempts are like not knowing how much the wood can hold up or not knowing how strong the screw can hold when screwed into the wood.

3.2. Hardware Issues

Since this is the first time we developed electronics for a product everything was new to use. There were various problems with electronics while working on this project, and there were many parts that were trial and testing purposes only.

One example was finding sensors to use for this project. There are a few specialize electronics store in the city that we found had sold the type of parts we need. We got what we could obtain from them and also order parts online. The first sensor we got was an OPB 704 sensor.

Figure 1: OPB 704 Infrared emitter and detector sensor

We thought this sensor was an infrared sensor that would tell if there was an object nearby. From varies website we thought that it would emit infrared signal and look for a response when the signal bounce off a nearby object. However it turns out that this sensor could not tell if there was an object near it or not. After testing to make sure we were using this sensor properly, we discovered that this sensor could only recognize light coming from outside sources which did not fit in our needs. The next sensor we tried was a Sharp GP2Y0A21 IR sensor that produced better results when trying to identify if an object passed through its given range or not.

Figure 2: GP2Y0A21 Infrared proximity sensor.

This sensor was able to detect objects like we hope it could and would recognize if there was an object that was directly in front of it. For our needs, we would use a wide angle sensor instead of a narrowed vision one, like the GP2Y0A21 IR sensor. Other problems with this sensor were the output voltage it produced because it interfered with the controller coding. When there was something about 10 to 20 cm in front of it, the output voltage would cause the microcontroller to read it as a “high”. Whenever an object was outside the 10 to 20 ranged boundary (including less than 10 cm away), the microcontroller would be unable to tell that there was an object there. This made it hard for this sensor to be use to tell if there is an obstacle in the way at certain ranges and required precision at all times.

Another problem we faced was providing power for the motors. The two motor, used by the linear actuator, require 12 volt at 1.5 amps to 2 amps each to run. This is a lot of power and we had problem working around this. The first problem was acquiring this much power. Due to cost and the stock at local electronics stores, we got a 12 volt at 2 amp regulated adapter. This was not enough voltage for our motor driver to power the two motor. So instead we had the microcontroller run only one motor at a time and switch between the two of them quickly. This would produce a somewhat jagged movement but would produce the movement needed regardless. However this seems to put lot of strain on the driver (might have led to the driver breaking). Also, even with the software solution, the 12 volt regulated adapter did not provide enough power the motor needed. One motor did not have enough power to move, while the other motor move slowly and couldn't support much weight. Other issues cause by requiring lot of power was we needed to get wire that could support this voltage. We got 16 gauge wires which are able to transfer this voltage, but the wire was hard to work with when using it to connect components due to its size and rigidity. The ends of the wires were really thick and were made up of tiny copper wires which were hard to attach to other parts.

Other problems we faced were the durability of parts. As mention above, we had a problem of one our motor driver breaking. At first we were able to move both motor using the motor driver. However, after that test we were only able to move one of the motor with the driver. While trying to fix this problem we discover we were only able to move the one motor in only one direction. After more testing the motor driver stopped working completely and we declared that the driver was broken.

We also had a problem of one of our Ardiuno microcontroller breaking. At first we experiences problem connecting to the microcontroller. We were able to fix the initial problems through resetting the system and restarting connections but later we were unable to connect to the microcontroller at all. We believe that either the microcontroller chip or the USB bus breaking due to using too much power or careless misusage.

4.0. Changes of Project

4.1. Frame Design

The actual prototype built is the combination of the initial frame design with the modifications of the solution to the mechanical issues. The initial frame design has a motor directly connects to the arm to rotate 90 degree and the modification of this part of the design is to have the motor rotate the arm by using a spiral rod to push a track linearly. This method allows the motor to also acts as a support pillar. Another modification is required for the body of the system to be place in the back of the legs instead of the front because the previous modification of the motor does not allow the body to fit in the front of the system.

4.2. Hardware

There were a few ideas that we had initially set out to accomplish at the beginning of the project but were either changed or dropped due to various reasons which include not being able to obtain such a part to fit our needs to not having enough time or knowledge to implement such a component into our system.

One of the changes that we had to change was a sensor that was able to detect obstruction throughout the system in various locations. We required a sensor that was able to stop the motor if any obstacles were in its way for safety reasons but while looking for such a sensor to buy we were not able to find a type that fit our conditioning. Moving to the next best type of sensor we could find that would potentially fit our conditions was using a proximity sensor to detect objects from certain distances. Since proximity sensors will only detect what is directly in front of them, we would require a few of them working together to cover the most critical (dangerous) areas of our system. Another change that we had in our system was the type of button switches that we were planning to use. The initial thought were to have tactile buttons that would switch the circuit on all the time only when you kept the button pressed but would turn off the circuit when it was let go. The initial thought was that this would be safer for the user since they can just let go of the button to spot the system from moving at anytime. However during our search for such buttons, we were unable to find ones that fit our size and functional requirements. Ones that did fit our functional requirements, lacked in the size requirements or visa versa. Therefore we decided to go with what was the correct size for our build and modify our functionality to fit what we could find.

4.3. Software

There were changed made to the software from the initial function specification. This was due to changes made to other part of the project. There were various hardware problems that we ran into while working on this project. Instead of spending more money buying new parts to fix these problems we tried to use a software solution to solve these problems instead. However this potentially created more problems that we encountered which we could not find a software solution for.

There were various hardware issues that require a software solution to overcome. The main problem was that we did not have enough power to control both our linear actuator.   We solve this problem by having the software run the motor independently one at a time. The software would turn on one motor and let it run for a while and then it would turn it off and turn on the other motor and let it run. Using this method we are able to move the motors as if they were moving at the same time. While waiting for one of the motor to run, the program is not able to detect interrupts so the software is not as responsive as we would like (but still had acceptable response time).

There were some problems that we were unable to overcome with software. One problem was that we could not find a good proximity sensor to detect obstacles everywhere. No matter what we did with the software, we could not overcome the problem of a part that didn't work as intended. We decided to remove the proximity sensor from the software because we did not have the hardware to detect obstacle over such a wide area. Another issue was that we could not find a good way to identify the positioning of the lift. We had force sensors that are used to tell when the lift reached the limits but we had no way to tell the position of the lift in between those limits. So we remove the requirement of knowing the position of the lift. This also removes the feature of the software maintaining a fix position. Since it is impossible to know where the lift currently is, it is impossible for the software to keep the lift in a fixed location. However even though the software for this was remove, the lift is able maintain a fixed position due to the way the motors were designed.   Another feature we remove was the software moving by to it "home position" automatically. We had problem getting the hardware in place for this feature so we did not include it in the software.

4.4. Motors

Initially, our plan was to have one rotational motor at a joint and a linear actuator to do our required movement. Our required movement had to move the legs of a person sitting in bed from the floor up to the bed. This movement is from bottom corner of the device moving in a curve to the opposite corner of the device. After having trouble with finding a motor strong enough to do our required rotational movement, we decided to deviate from the original design and find another way to complete the requirement. We decided to use two linear actuators instead of one rotational motor and one linear actuator. We integrated the actuators into out desired movement where the paddle movement would be as close and smooth as possible as if it was to be with one rotational motor and one actuator. The outcome is a movement that will satisfy the requirement but we believe that it would be a smoother movement with a rotational movement.

5.0. Future Developments

5.1. Frame Design

The prototype of the system is one of the images for lifting the legs onto the bed. With the constraints of limited money and supply, the system has been build accordingly. For future development, the system prototype can be improved in many ways. The structure of the system prototype can be build lighter by using plastic instead of wood. This method also invokes on safety because plastic is a softer and less rugged material than wood. The skeleton of the system prototype can be build lighter and stronger by using material similar to steel property. Carbon fibre is a good example of such material considering the lightness and durability.

The future development for the concept can also be improved on. For the prototype, a linear track actuator was used to get the rotational motion and a supporting pillar for the weight of the arm. Instead of using the linear track actuator, hydraulic actuator is also a better option and has the capacity of supporting the weight and minimizing the size when recoiled. The legs of the system prototype are made of wood. For future design, the leg should be build with light weight metal and be able to adjust the height to fit all type of bed heights. Another important improvement for future design is the method to attach the system along the bed. The future design can have a strap that attach to the side of the bed instead of around the bed matrices.

5.2. Hardware

For future consideration, this product could optimize the user's safety by adding more obstacle detectable sensors (ex infrared red and ultra sound sensors) to critical locations around the frame. To accommodate usability of the product, we will be adding a voice recognition system on top of the manual control. This will require both electronic and software components to integrate. Improvement to the motors can be made by replacing the current motors with lighter, and more power efficient motors. These motors will be accompanied by gear boxes that can enhance their output power. To compact our circuit components, we will create and manufacture a PCB design and encasing the system with an enclosure.

5.3. Software

The current software is able to meet the needs of the current system but development is still needed for a final product. Since software is used to help different parts of the system interact with each other, future development of the software would depend on the development of other parts of the system. Changes to different parts of the system could result in changes to the software. Also added hardware could require additions to the software so there are no conflictions between operations.

Changes to the hardware of the bed lift could cause changes to the software. One likely change is replacing the current adapter with a more powerful one. After getting a new adapter the motor driver should be able to move both actuator at once so having to switch back and forth between the actuator would not be needed anymore. Other changes to the current program would be getting new sensors. By adding new sensor to the system the software would need to be changed to handle additional interrupts. A final addition to the final software aspect of the product would be reincorporating the "Home Position" sequence command which allows the lift to return to its final position automatically after use.

5.4. Motors

In the future, Improvements can be made on the motors to make the device more suitable for its requirements. The improvements on the motors would be changing the linear actuator doing the outward motion and replace it with a rotational movement which can be done with a strong rotational motor. This will result in a much safer design and a smoother movement.

6.0. Individual Experiences

6.1. Michael Quong

Things I learned during these past four months were far too many. Some lessons were far too stressful that doubt make me doubt myself and other lessons were very thought provoking that made me understand why things occur the way they are. In large companies, they are always looking for individuals that can inspire a team, motivate them to work for them and manage a task to success. Through my experiences as this groups project manager is that this skill is not something that comes very easily or can be learned on the fly. Project management is a very difficult thing to do and deal with on a day to day basis. The stress of having to know that others are counting on you to lead, and guide them to this promise land of success is the most challenging task one could be ever have on their to do list. I learnt a lot from my trial at being a project manager through the various tasks I was responsible for such as setting up dates, making sure everyone is ready, and ensuring that everyone is supplied with enough information to succeed every day. By the end of this trial, all I can say and feel about my work and commitment is that I may not be ready to lead a group of people all on my own without some more experience and guidance from those that are more experienced in project management. Maybe times throughout the term I felt so lost, isolated and confused at what to do next or where to go from here. I also felt that as the manager of the group, everyone else is here looking at you for the answer or looking at you to make the tough calls and decisions which may or may not lead the project down the correct path to success. As a manager, I felt burdened with all these tasks and decisions, frightened about which decision is the correct decision because the ideas I choose don't only affect myself and the project that I am working on but also affects those around me that are there to help me work on these project. Having other individuals fates in my hands seemed like something I am not ready to have. However on the contrary, being the manager of a project meant I have people that follow my command and follow out my vision of how the project is to be. I have found it is equally stressful having count on others to complete your vision and objective, and not knowing if what they will give you would will be what you were expecting in your mind. Sometimes things seemed easier if you did them yourself but with an idea this big it would be impossible to do be everywhere and watch how things turn out or do things the way you expected them to. This project has taught me a lot about myself and a lot about others. It has taught me things I wouldn't have experienced before if I had not taken the chance at the role. It has taught me that people are different from this point of view and there. This project as the project manager has taught me valuable lessons, given me compelling thoughts and a drive to what would come next. (that is, when I am ready for them)

6.2. Martin Wong

This project has taught me many things about the field of engineering, even though this project is a small scale compare to other engineering project out in the world. Similar to any projects, to design something from nothing requires an accurate plan that includes size and measurement so it easier for the builder to see how to build the system. I have made many mistakes when making this project, which includes not properly test out a design concept before actually making the design. This mistake has lead to not properly make good use of time. Another experience I have learnt as part of engineering is to create something with what I have. Ideally, if there is something that does what you need as a part of the design, then putting the complete design together would be really easy; however I learn that I might not always have this something so I need to make another thing to do this something with whatever I have. Overall, this project has been a great experience and I will definitely reflect on this experience the next time I work on another project.

6.3. Andrew Yip

It was an interesting experience working on this project because I got to work with a lot of interesting stuff that I normally do not get a chance to work with. I learn a lot about things that are not normally covered in school. Since I am in computer engineering, my courses are more on software and chip design than on electronics. So this project gave me a chance to work with electronics parts, which I normally do not get the chance to work on in computer engineering. I got to work with H bridges and power supply to control a motor. This was interesting because I learned a lot about designing circuit to power a motor. I also got to work with switches and sensor for inputs. Beside things that I normally do not work with, I got to more experiences doing real time embedded programming on an Arduino microcontroller. Finally this project taught me what is required to design and build a product. For previous courses, I have design a product but never built a prototype for it. I learned a lot about the challenges involved in going from the drawing board to a working model.

6.4. Amer Kalla

I consider myself very lucky to work on this project. When we first discussed the idea I was a little skeptical regarding whether or not the idea was feasible and if we could finish it on time.

After the months of work, I was very happy that we were able to finish such a device. Our device was finished and worked after all the modifications. I learned a great bit from working on the project. It also gave me experiences and knowledge that I couldn’t have simple learned behind a book or a desk. The hand on experience was priceless. Also working on this project made me change my attitude towards ideas and innovations. Finishing this project gave me hope more than anything else to do great and peruse the impossible. The most bit I learned was from working of the following topics:

- Research on the topic, and finding terms of usability and medical purposes
- Safety regulations and research
- Hardware, Mechanical movement and motors